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# SOME ASPECTS OF SCIENCE EDUCATION IN EUROPEAN CONTEXT

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**Abstract:** Some up-to-date problems in science education in European context are treated in this paper. The characteristics of science education across Europe are presented. Science teachers' general competencies are underlined. An example of problem-solving as teaching method in chemistry is studied in knowledge based society. Transforming teacher practice across the Europe is a long-term project and will require significant investment in continuous professional development. Better science teaching is grounded, first of all, in improving the quality of teacher preparation and in making continuing professional education available for science teacher.

**Zusammenfassung:** In dieser Schrift werden einige aktuelle Probleme in der europäischen wissenschaftlichen Erziehung behandelt. Die Merkmale der wissenschaftlichen Erziehung quer durch Europa werden dargestellt. Die allgemeinen Kompetenzen der Wissenschaftslehrer werden hervorgehoben. Ein Problemlösungsbeispiel wie die Lehrmethode in Chemie wird in der wissenschaftlichen Gesellschaft untersucht. Die Übertragung der Lehrerpraxis quer durch Europa ist ein Langzeitprojekt und wird eine deutliche Investition in der andauernden Berufsentwicklung erfordern. Besseres wissenschaftliches Lehren ist zuallererst begründet in der Verbesserung der Qualität der Lehrervorbereitung und in der Zurverfügungstellung von fortgesetzter beruflicher Erziehung für Wissenschaftslehrer.

**Key words:** science education, continuous education, knowledge based society, problem-solving

## 1. Introduction

In the past two decades, a consensus has emerged that science should be a compulsory school subject. Most school science curricula do attempt to serve two goals – that of preparing a minority of students to be the next generation of scientists – and that of educating the majority in and about science, most of whom will follow non-scientific careers. For the future scientist, their education best begins with the fundamentals of the discipline. In this approach, only students who reach a relatively high level of education in science develop a sense of the explanatory coherence of science and its major ideas. In addition, the standard school science education has consistently failed to develop anything other than a naive understanding of the nature of science, commonly called "how science works". To understand the role of science in such deliberations, all students, including future scientists, need to be educated to be critical consumers of scientific knowledge. Improving the public's ability to engage with such socio-scientific issues requires, therefore, not only knowledge of the content of science but also knowledge of 'how science works' – an element which should be an essential component of any school science curriculum (Osborne & Dillon, 2008).

The national teacher training systems in Europe are based in traditional standardized models not taking into account, most of the times, the outcomes of the research in the field of science teaching and practice. As a result they are losing the chance to respond to the challenges of the 21st century and they are failing to capture young people's interest for scientific ideas.

Science education in Europe has recently been the focus of considerable attention. The predominant factor behind this interest is the declining numbers of young people choosing to pursue the study of science and the threat this poses to the Lisbon agenda which seeks to place the EU at the forefront of the knowledge economy of the future. The one area, however, in which there is a common trend is in the decline of student attitudes to science (http://scied.unl.edu/pages/preser/sec/articles/unlcomp.html)

## 2. Some features of Science Education in Europe. Science teacher competences

Many researchers, trainers and associations, currently working on proposing standards for science teachers' education and profession, have tried to analyse the new role characterising the science teacher by focusing on the involved "*competencies*". This concept is considered relevant in all professional fields and particularly in education research, given the fact that these processes are based on interactions amongst human beings.

The competencies' categories take into account the reported literature and keep in mind the situation of the science teacher education in each partner country. As a result the profile of the science teacher is defined through two broad categories defined as General Characteristics and Professional Competencies:

- ***General Characteristics*** are, in many cases, independent from subject or disciplinary content. They refer to the teacher general knowledge, verbal knowledge and cultural level. Teacher beliefs and attitudes about teaching and learning play also a relevant role. In fact, teachers may have varying levels of motivation to teach and be motivated by goals not entirely consistent with increased student learning. A variety of influences, both internal and external to the teacher, can motivate the teachers both toward and away from what they believe to be good instruction.
- ***Professional Competencies****,* that can be shaped and altered by professional development activities and are referred to the subject and related skills (Naumescu, 2008).

**Science Education General Competencies are the following:**

**1.** The teacher candidate understands the central concepts of science, tools of inquiry, and structures of the discipline and can create learning experiences that make science personally, vocationally, and academically meaningful and relevant for students. (http://www.cise.msstate.edu/)

Central concepts of science include:

- Unifying Concepts and Processes
- Inquiry
- Physical Science
- Life Science
- Earth Science
- Science and Technology
- Science in Personal and Social Perspectives
- History and Nature of Science

**2.** The teacher candidate understands that children construct meaning and can provide learning opportunities that support their intellectual, social and personal development. This requires that the teacher candidate apply this competency from a constructivist view:

- Understand how learning occurs and is facilitated,
- Children individually and socially construct science knowledge,
- Learning is an active process by which students individually and collaboratively achieve understandings,
- All students come with diverse ideas, skills, student misconceptions or naïve conceptions and experiences which shape learning.

**3.** The teacher candidate understands how students differ in their approaches to learning and creates instructional opportunities that are adapted to diverse student needs including: gender, cultural or ethnic background, disabilities, aspirations, or interest in science.

**4.** The teacher candidate understands and uses a variety of instructional strategies to encourage students' development of critical thinking, problem solving, and performance skills and matches these strategies to content, learning theory and student diversity.

**5.** The teacher candidate uses an understanding of individual and group motivation and behavior to create a safe, ethical, and legal learning environment that encourages positive social interaction, active engagement in learning, and self-motivation.

**6.** The teacher candidate uses knowledge of effective verbal, nonverbal, and media communication techniques to foster active inquiry, collaboration, and supportive interaction in the classroom.

**7.** The teacher candidate plans instruction based upon knowledge science and students in the context of the community, and curriculum goals.

**8.** The teacher candidate understands and uses a variety of formal and informal authentic assessment strategies to evaluate and ensure the continuous intellectual, social and physical development of the learner and encourage student self asssessment.

**9.** The teacher candidate is a reflective practitioner who constantly analyzes, evaluates, and strengthens their practice in order to improve the quality of their students' learning experiences.

**10.** The teacher candidate fosters relationships with school colleagues, parents, and agencies in the larger community to support individual students' learning needs and overall teaching practice.

**11. Contexts of Science Education**

Accomplished science teachers create opportunities for students to integrate and coordinate the context of science with other subject areas.

**12. Training in Human Relationships**

Science Teachers are aware of and act on a knowledge related to social, ethical and legal aspects of teaching.

- An awareness and understanding of the values, lifestyles, contributions, and history of a pluralistic society.
- The ability to recognize and deal with dehumanizing biases, including, but not limited to, sexism, racism, prejudice, and discrimination, and an awareness of the impact such biases have on interpersonal relations.
- The ability to translate knowledge of human relations into attitudes, skills, and techniques which result in favorable experiences for students.
- The ability to recognize the ways in which dehumanizing biases may be reflected in instructional materials
- Respect for human dignity and individual rights.
- The ability to relate effectively to other individuals and to groups in a pluralistic society other than the teacher's own (http://scied.unl.edu/pages/preser/sec/articles/unlcomp.html).

Many countries have seen declining numbers of students choosing to pursue the study of physical sciences, engineering and mathematics at university. For instance, from 1993-2003 the percentage of S&T graduates has fallen in Poland, Portugal and France. The same is true in Germany and the Netherlands. In addition, the percentage of graduates studying for a PhD – the most common route to becoming a professional scientist – has dropped in all European countries. The consequence is that the supply of scientists to sustain knowledge economies, which are heavily dependent on science and technology, is perceived as a significant problem. This predicament was addressed in a major report – *Europe Needs More Scientists* – which laid out a series of recommendations to address the issue. The ROSE study of students' attitudes to science in more than 20 countries has found that students' response to the statement 'I like school science better than other subjects' is increasingly negative the more developed the country (Figure 1). Indeed, there is a 0.92 negative correlation between responses to this question and the UN Index of Human Development. In short, the more advanced a country is, the less its young people are interested in the study of science.

In the context of the EU there is, however, less of a recruitment problem in Southern and Eastern Europe, raising the question of whether there is a problem or whether it is simply a mismatch between supply and demand. However, data presented in the EU report *Europe Needs More Scientists* show that the number of researchers across the EU is 5.7 per 1000 of the workforce whilst the comparable figures for Japan and the USA are 9.14 and 8.08 respectively, suggesting that the problem has a pan-European dimension. Moreover, if students' attitudes towards school science remain as negative as they are currently, the issue of the supply of scientists, and whether Europe is producing sufficient, will be exacerbated and not diminished (Osborne & Dillon, 2008).

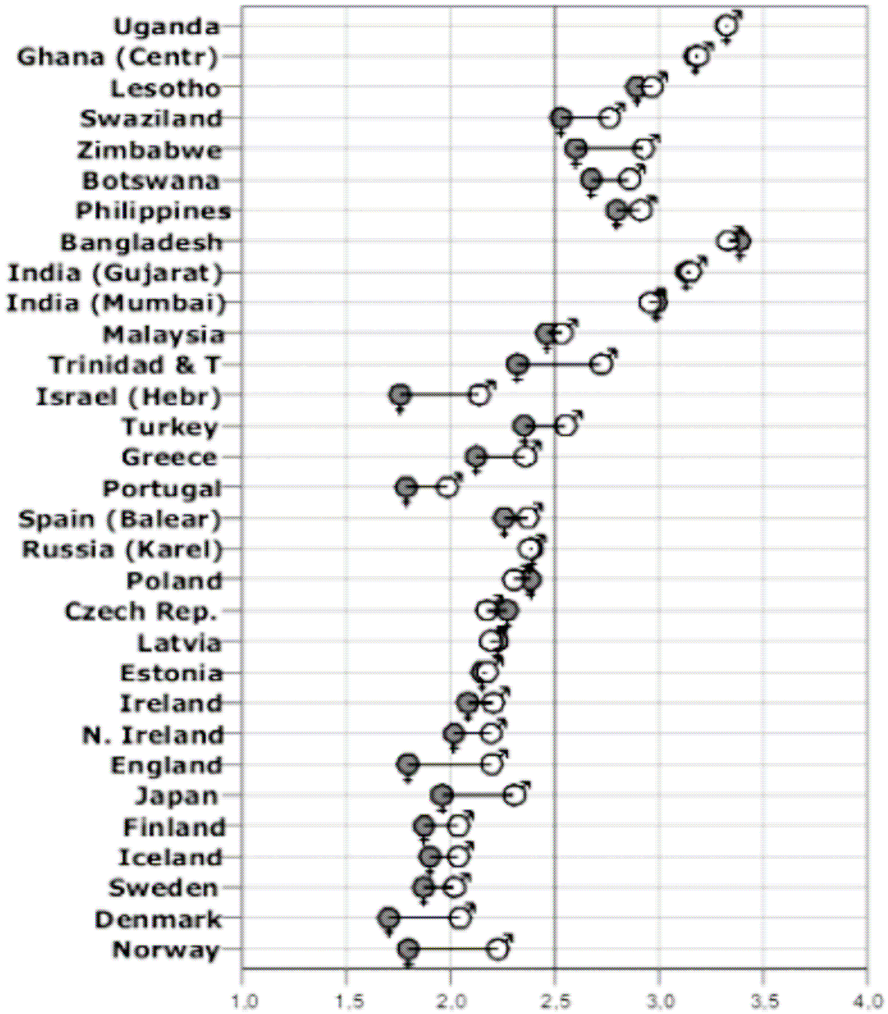


*Figure 1. Data from the ROSE study showing students' responses to the question "I like school science better than most other school subjects" (1 – strongly disagree, 4 – strongly agree; dark symbols – female/light – male); (Osborne & Dillon, 2008).*

## 3. Suggestions for Science Education

For science education in "knowledge based society" it would be useful to follow some suggestions:

- More attempts at innovative curricula and ways of organizing the teaching of science that address the issue of low student motivation are required. These innovations need to be evaluated. In particular, a physical science curriculum that specifically focuses on developing and understanding of science in contexts that are known to interest girls should be developed and trailed within the Europe.
- European countries need to invest in improving the human and physically resources available to schools for informing students, both about careers in science-where the emphasis should be on why working in science is an important activity-and careers from science where the emphasis should be on the extensive range of potential careers that the study of science affords.
- There is a lack of a clear vision across Europe of the purpose and goal of formal science education. On the one hand, school science is essential to produce the next generation of scientists, engineers and doctors and, on the other hand, it is a dominant part of contemporary culture – a way of knowing about the material world of which all should have some rudimentary understanding. Evidence would suggest that it is the first of these goals that largely determines the nature of school science at the expense of a curriculum that might meet the needs of the majority.

- Developing and extending the ways in which science is taught is essential for improving student encouragement. Transforming teacher practice across the Europe is a long-term project and will require significant and sustained investment in continuous professional development (Naumescu, 2006).

## 4. The problem- solving as teaching method

**a) A useful model in science teaching**

In 1957 Georg Polya formulates in his book "How to solve it" the most important four steps, which can be used in problem solving. He thought special in mathematics problems, but his ideas can be successfully used in other exact sciences, as physics, chemistry, biology and informatics. (Polya, 1957)

Those points are the following:

I. UNDERSTANDING THE PROBLEM

**1.** You have to *understand* the problem.

- What is the unknown? What are the data? What is the condition?
- Is it possible to satisfy the condition? Is the condition sufficient to determine the unknown? Or is it insufficient? Or redundant? Or contradictory?
- Draw a figure. Introduce suitable notation.
- Separate the various parts of the condition. Can you write them down?

II. DEVISING A PLAN

**2.** Find the connection between the data and the unknown. You may be obliged to consider auxiliary problems if an immediate connection cannot be found. You should obtain eventually a *plan* of the solution.

- Have you seen it before? Or have you seen the same problem in a slightly different form?
- *Do you know a related problem?* Do you know a theorem that could be useful?
- *Look at the unknown!* And try to think of a familiar problem having the same or a similar unknown.
- *Here is a problem related to yours and solved before. Could you use it?* Could you use its result? Could you use its method? Should you introduce some auxiliary element in order to make its use possible?
- Could you restate the problem? Could you restate it still differently? Go back to definitions.
- If you cannot solve the proposed problem try to solve first some related problem. Could you imagine a more accessible related problem? A more general problem? A more special problem? An analogous problem? Could you solve a part of the problem? Keep only a part of the condition, drop the other part; how far is the unknown then determined, how can it vary? Could you derive something useful from the data? Could you think of other data appropriate to determine the unknown? Could you change the unknown or data, or both if necessary, so that the new unknown and the new data are nearer to each other?
- Did you use all the data? Did you use the whole condition? Have you taken into account all essential notions involved in the problem?

III. CARRYING OUT THE PLAN

**3.** *Carry out* your plan.

- Carrying out your plan of the solution, *check each step*. Can you see clearly that the step is correct? Can you prove that it is correct?

IV. LOOKING BACK

**4.** *Examine* the solution obtained.

- Can you *check the result?* Can you check the argument?
- Can you derive the solution differently? Can you see it at a glance?
- Can you use the result, or the method, for some other problem? (Polya, 1957)

**b) Solving a problem from chemistry: the molecular formula of an organic substance using Polya's four steps**

An organic substance A has the following composition: C: 80.00% and H: 20.00% and the molecular weight is M=30. Establish the molecular formula of substance A.

To solve the problem, students have to elaborate the four steps used by teacher in problem-solving.

UNDERSTANDING THE PROBLEM: The know data refers to the components of the substance A and the unknown is the molecular formula of substance A, more precisely how many carbons and how much hydrogen the substance contains.

DEVISING A PLAN: (it can be elaborated frontal, with the help of the students).We present here some typical questions and waited answers for the problem:

Teacher: In which way can you find the "brute formula"?

Student: We have to divide the percentage of each element with its atomic mass and then to divide the obtained value with the smallest value.

Teacher: How can you relate the "brute formula" with the molecular formula?

Student: The "brute formula" offers us the report between the atoms that give the molecular formula.

CARRYING OUT THE PLAN: The concrete calculations are: C: 80/12=6.66 gram-atom and H: 20/1=20 gram-atom. The smallest is 6.66, so we obtain: C: 6.66/ 6.66=1 and H: 20/6.66=3. The "brute formula" is: $(CH_3)_n$ . Then we connect it with molecular formula: 12n+3n=30; n=2 and we obtain the molecular formula $C_2H_6$

LOOKING BACK: The substance A is buthene (alkene)

## 5. Conclusions

The science teachers have to know the different types of arguments and argumentation, to favour logical and empirical demonstration, and to use with consciousness other arguments (by authority, by strength, by example, by analogy or metaphor, etc.).

If they don't assume these epistemic positions, they will transmit, even without any intention, their own values, philosophy or ideology.

In the perspective of a pedagogy based on competencies, the practices are the main goal of the science teachers training.

(1) Scientific processes (hypothetico – deductive process) for observations, experiments etc;

(2) Research of information (bibliography) and critical analysis of this information;

(3) Realization of didactical situations (problem based situation, pedagogy of project, etc.);

(4) Management of these situations;

(5)Scientific communication (written reports, oral speeches, drawings, diagrams & other images);

(6) Evaluation

Good quality teachers with up-to-date knowledge and skills are the foundation of any system of formal science education. Systems to ensure the recruitment, retention and continuous professional training of such that individuals must be a policy priority in Europe (Report E.C., 2001).

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